Washington State University-Pierce County Low Impact Development Pilot Project Monitoring

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Abstract

Pierce County is examining the application of new Low Impact Development (LID) guidelines to more effectively manage stormwater and protect streams, lakes and wetlands. Public and private partners in this effort are currently designing the first LID residential project in the Puget Sound region with construction scheduled to begin summer 2003.

The 8.27-acre site, located in northern Piece County, is representative of the challenging soil conditions in the region and is bordered by a salmon bearing stream. The project will incorporate cluster design with accessible open space, rain gardens, porous surfaces, minimal excavation pin foundations, native vegetation and soil restoration, enhanced stream buffer systems, and other small-scale, dispersed stormwater controls. The central goals will be to design an integrated LID system that more closely mimics native hydrologic function to protect adjacent stream values, enhance groundwater recharge, as well as construct an affordable and livable neighborhood.

Research investigating the stormwater management characteristics of bioretention, soil enhancement, and other LID practices that are integrated into a stormwater management system does not exist for this region. Monitoring the performance of the Pierce County pilot project provides a tremendous opportunity to determine the appropriate guidelines for the application of LID in the Puget Sound region. The primary goal for the monitoring program is to assess the performance of individual LID practices and evaluate the effectiveness of integrating these practices to more closely mimic pre-development hydrology.

Currently, pre-construction monitoring equipment has been installed and data collection is in progress. The presentation will focus on the process for implementing LID in Pierce County and the Puget Sound region, as well as the project and monitoring design.

Background

Urbanization and the associated changes in the movement of stormwater over and through the landscape are some of the greatest and most complex threats to water quality, water supplies, and aquatic habitat in the Puget Sound region. The transition from a forested landscape to a built environment increases impervious surfaces from roads, parking areas, sidewalk, rooftops, and compacted soils. Native vegetation and the upper soil layers that evaporate, transpire, store or infiltrate stormwater are typically removed. Water quality is impaired as stormwater flowing from impervious surfaces collect and convey oil, heavy metals, pesticides and other pollutants to streams, lakes, wetlands and the Puget Sound. The quantity and timing of stormwater flows also change dramatically. Overland flows, shallow sub-surface flows, and associated stream discharges increase significantly during winter, spring and summer precipitation events.

Current stormwater practices efficiently collect and convey precipitation from residential and commercial development to control ponds. Stormwater control design and maintenance standards often do not protect streams and wetlands from increased water volume discharged from urbanized landscapes. The change in the quantity and timing of stormwater runoff can significantly erode and altered stream channel form. As a result, aquatic habitat and the ability of fish, insects and other stream life to survive are degraded.

Low Impact Development is a land development and stormwater management strategy that emphasizes protection and use of on-site natural features integrated with engineered, small-scale stormwater controls at the parcel and subdivision scale to manage stormwater and maintain or more closely mimic pre-development watershed hydrologic functions. Pre-development or natural hydrologic function is the pre-disturbance balance among the overland flow, infiltration, storage, groundwater recharge and evapotranspiration characteristics of the forested landscape predominant in the Puget Sound region. Low Impact Development strategies focus on evaporating, transpiring, and infiltrating stormwater on site through native soils, vegetation and bioengineering applications, rather than conveying stormwater—at increased volumes—through large structural systems to streams and wetlands.

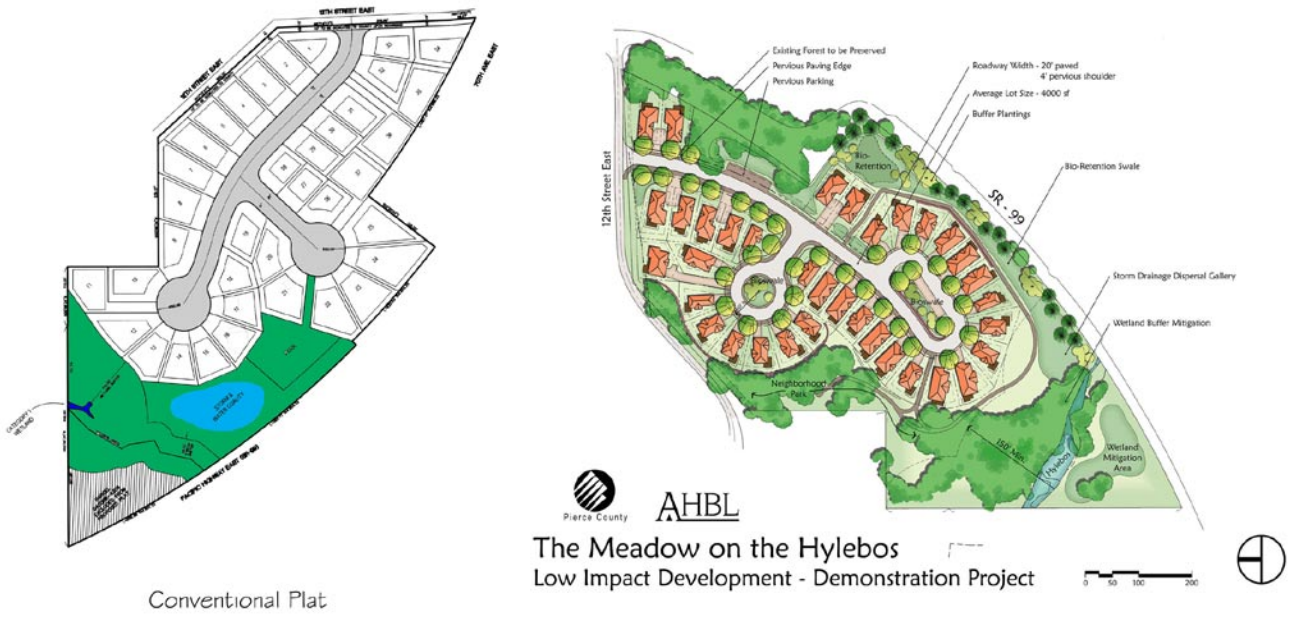

Figure 1.

For the past five years Washington State University, Puget Sound Water Quality Action Team, SCA and AHBL Engineering and others have conceptually examined new Low Impact Development designs. The region is now entering a new phase to implement pilot projects, test specific designs and applications, and develop guidelines for LID stormwater systems.

Pierce County Pilot Project Design and Implementation

The growing awareness of stormwater impacts, as well as Endangered Species Act listing of salmonids, NPDES permits, and more restrictive state stormwater management guidelines is encouraging larger jurisdictions to explore additional stormwater management tools. Pierce County is examining the application of new Low Impact Development (LID) guidelines to more effectively manage stormwater and protect streams, lakes and wetlands. Public and private partners in this effort are currently designing the first LID residential project in the Puget Sound region with construction scheduled to begin summer 2003.

The 8.27-acre site, located in northern Piece County, is representative of the challenging soil conditions in the region and is bordered by a salmon-bearing stream. The project will incorporate cluster design with accessible open space, rain gardens, porous surfaces, open conveyance systems, native vegetation and soil restoration, enhanced stream buffer systems, and other small-scale, dispersed stormwater controls. The central goals will be to design an integrated Low Impact Development system that more closely mimics native hydrologic function to protect adjacent stream values, enhance groundwater recharge, as well as construct an affordable and livable neighborhood.

Low Impact Development is a new stormwater management strategy for local jurisdictions and, as a result, requires additional review to examine applicable variances and technical equivalency of stormwater controls. To reduce the risk for the owner and developer of the pilot project two projects were submitted: a conventional plat from the developer and the LID design from Pierce County (see Figure 1 for plat designs). This provided a backup plan already in review in the event that the LID design was withdrawn for any reason. All interests are now confident that the LID design will be approved and the conventional design has been withdrawn.

WSU Pilot Project Monitoring

Research investigating the stormwater management characteristics of bioretention, soil enhancement, and other LID practices that are integrated into a stormwater management system does not exist for the Puget Sound region. Monitoring the performance of the Pierce County pilot project provides an opportunity to assess the performance of individual LID practices and evaluate the effectiveness of integrating these practices to more closely mimic pre-development hydrology.

Figure 2.

Figure 3.

In late January 2003 pre-construction monitoring equipment was installed and data collection is now in progress. The monitoring plan focuses precipitation and energy inputs to the property; stormwater flows to the site from adjacent land uses, and surface and subsurface flow rates and volumes through and off the property. Due to limited resources, water quantity will be the focus for the pre- and post construction monitoring plan; however, basic water quality constituents will be monitored for the post construction phase as resources become available.

An onsite weather station records precipitation, temperature, relative humidity, wind speed and direction, solar radiation, and soil temperature (see fig. 2 for instrument locations). Two tipping bucket rain gauges—one set with the rim at four feet and the second with the rim at approximately 20 inches—provide redundant precipitation checks. The ground level gauge is connected to a graduated container to provide an additional rainfall measurement. The initial plan called for one gauge to be placed in a well with the rim at ground level, however, site conditions were very wet during and after installation and the well has remained flooded for much of the winter.

Surface water flows are measured using a flow meter (Data Industrial 200 Series) installed in a calibrated pipe (see Figure 3). A 1ft-x-1ft-x-1ft catch basin is located at the downstream end of a lined stilling basin with the calibrated pipe attached and exiting at the base of the berm forming the basin. The pipe is set level with a 90-degree bend at the outfall so that the pipe is continually full of water. Flow is registered as water moves through the pipe and past the sensor impeller. The pipe diameter is selected given the estimated flow range. Two of the surface flow gauges are 3-inch pipes with sensors registering flow ranges of 12 to 125 gallons/minute.

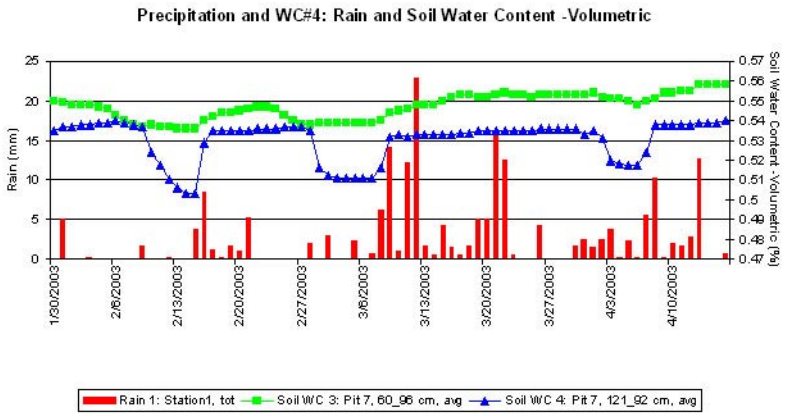

Figure 4.

The third station is a 2-inch pipe with a sensor registering a flow range of 5 to 55 gallons/minute. The pipe, flow meter configuration was installed instead of a weir or flume system as a relatively accurate (2% of the full scale range) and lower maintenance experimental method. Station #1 (most northern) was located to measure stormwater inputs entering the property through a culvert and Station #2 (next southerly station) was located at a natural swale outfall from a depressional area. Given the wide range of flows associated with stormwater, the pipe system has not performed adequately and does not register flows that are often present below 12 or 5 gpm. Data Industrial produces a more sensitive meter that will record a range of approximately 2 to 125gpm that may be installed for the final pre-construction phase if resources permit. Given the limitations of the pipe sensor system, a flume or weir system will be installed for the post construction phase to more accurately record a wider range of flows.

Subsurface water volume and flows are measured with time domain reflectometers (TDR, Campbell Scientific CS616) and piezometer wells. Transects for the TDR arrays were selected to examine different slope and elevation categories on the site, and be proximate to post construction locations. Five-foot deep pits were excavated at each TDR location; sensors were placed horizontally into the upslope wall of the pit at two and four foot depths, and then backfilled. Three piezometer wells (Remote data systems WL-40 and WL-80) are located on a transect from high to low elevation, and a fourth well is located near the lowest elevation of the property. The transect location was selected to sample different slope and elevation categories. The highest elevation piezometer will likely not be influenced by construction and will remain as a control and the lowest elevation wells (bottom of transect and most southerly well) are in locations where the ultimate outfalls of the LID stormwater system will be located.

Discussion

The pre-construction monitoring phase is nearly complete and all instrument locations (except for the highest elevation piezometer) will be surveyed, for comparison to post construction locations, and removed in July for initial surveying and grading. Data will continue to be collected through the pre-construction phase and quality checks completed at this time. Given the early development of the monitoring effort no data is presented in this report except for initial soil water content data as a discussion point.

The surface flow stations have proven problematic. The flow sensors did not measure low flows typical during small storms. The flows entering and moving through the property were much larger than anticipated during larger storms and as a result the stilling basins had substantial leaks. While the pre-construction surface flow stations will not supply defensible data, they are providing a general characterization of the property for sizing facilities to accommodate the much larger than anticipated stormwater input from offsite sources. Additionally, the experience provided in the pre-construction phase will increase the quality of the post construction effort.

The initial data from the soil water content or TDR arrays is interesting. The onsite soils are silt loams (estimated infiltration rates of .5 to 1.0 inch/hour), glacial lake-bed deposits and glacial till at depths ranging from 3-10 feet. Soil water volume at the two- and four-foot depths are apparently responding to relatively small precipitation events in till and silt loam locations often in 5-7 day time periods.

TDR transects will be installed at bioretention and bioswale locations (infiltration and open conveyance systems) to assess subsurface volumes and flow. The TDR technology may prove valuable for better understanding infiltration possibilities and lateral flows in till and other low permeability soils for small-scale dispersed controls typical in Low Impact Development designs.

The WSU Pierce County Pilot Project monitoring effort is in the initial phase of development. Monitoring will continue for a minimum of three years after construction and employ surface and subsurface instrumentation to assess the performance of individual LID practices and evaluate the effectiveness of integrating these practices to more closely mimic pre-development hydrology. The WSU Pierce County Pilot Project monitoring is one of very few efforts nationally assessing the performance of a complete LID residential design and provides an opportunity to more effectively develop guidelines for implementing Low Impact Development throughout the Puget Sound region.